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Corrosion Inhibition of Reinforcing Carbon Steel Bars by Potassium Dichromate in Acidic Media

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Abstract:

The effect of Potassium dichromate as inorganic inhibitor on the corrosion behavior of Reinforcing carbon steel Bars was investigated in (1 M) HCl as acidic medium at 20° C. Varied Concentrations of potassium dichromate (0.0001), (0.0004), (0.0008), (0.001) and (0.002) was investigated in study by using weight loss measurements at interval times (1-7) days and potentiodynamic polarization curves. From the result we obtain that the $K_2Cr_2O_7$ have a good inhibition effect in HCl medium. Also, we obtain that the inhibition effect increases with increasing the inhibitor concentration. Inhibition efficiency was calculated for the different concentrations of potassium dichromate.

Keywords: Inhibitors, corrosion, carbon steel, potassium dichromate

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1. Introduction:

Metals are extracted from their ores by reduction process. when metals come in contact with the environment, especially oxygen and moisture, they deteriorate this process, we call, corrosion. corrosion is the desire of pure metals to go back to its original state of ores. corrosion is a natural, spontaneous and thermodynamically stable process. the process of corrosion can be controlled but it cannot be prevented. corrosion impacts many aspects of our lives. The economic costs of corrosion are very high.

The term steel is usually taken to mean an iron - based alloy containing carbon in amounts less than about 2%. Carbon steel (sometimes also termed plain carbon steels, ordinary steels, or straight carbon steels) can be defined as steels that contain only residual amounts of elements other than carbon, except those (such as silicon and aluminum) added for deoxidation and those (such as manganese and cerium) added to counteract certain deleterious effects of residual sulfur. However, silicon and manganese can be added in amounts greater than those required strictly to meet these criteria so that arbitrary upper limits for these elements have to be set; usually 0.60 % for silicon and 1.65 % for manganese are accepted as the limits for carbon steel. The carbon steels of interest in this work are those with carbon equal to 0.33 %. And the percentage of all alloying elements in the sample were determined.

The increase in the volume of the corrosion products in relation to the initial reinforcing steel initiates tensile stresses which cause appearance of fissures, cracking and setting apart. the phenomenon makes it inevitable for researchers to find out more ways of reducing rebar corrosion rate. corrosion can be controlled by several methods. such methods include anodic protection, cathodic protection, rebar coating and the use of inhibitors. Amongst inhibitors widely employed to minimize corrosion of many metallic structures in various environments are nitrates, benzoates, phosphates, chromates and borates. Nitrate based inhibitors, though older than chromate-based corrosion inhibitors have along established reputation for effectively inhibiting corrosion of steel. inhibitors containing sodium and potassium ions have the tendency to maintain the pH between 12.5 and 13.5. under this PH levels steel attains a high corrosion potential that leads to passivity.

This work evaluates the inhibition performance of potassium dichromate inhibitor on carbon steel immersed in 1 M HCl at 20 ° C.

2. Experimental:

Reinforcing steel bars of diameter 18 mm were used for the experiment. The samples were machined in different forms. For weight loss, the specimens were made in the form of discs (14 mm diameter and 10 mm thickness). For polarization measurements, the specimens were machined in the form of rods (7 mm diameter and 10 mm length). Machining the samples was carried out at a low rate in order to avoid elevation of temperature, the machining was operated in a stream of cooled kerosene.

The chemical composition of the alloy used was determined using emission spectroscopic technique. The chemical composition of the sample is given in table (1).

1 M HCl was used as a corrosion medium and potassium dichromate of different concentrations was used as a corrosion inhibitor.

Corrosion Measurements were applied by two techniques, weight loss and potentiodynamic polarization curves. For weight loss, the initial weight of the cleaned discs was recorded then each sample was suspended in a cell contain 80 ml of 1.0 M HCl as a test solution without and with different concentrations of studied inhibitor at 20 °C, at interval time (1-7) days. At the end of the immersion time, the sample was removed from the cell and its exposed Surface area was washed with hot conductivity water during brushing with hard plastic brush to remove any corrosion products on the surface. Then the weight loss of each sample was recorded.

Electrochemical polarization experiments were carried out in a glass cell with three different types of electrodes of capacity 100 ml. The samples were weld from one side to a copper wire used for electric connection. The samples were embedder in a glass tube of just larger diameter than the sample. Epoxy resin was used to stick the sample to glass tube. A constant amount of test solution was put in glass cell. after each experiment the surface of all samples was polished with emery papers, degrades with acetone, washed with distilled water and dried. The electrode was allowed to attain a steady state potential value 30 min before starting the measurements. The corrosion parameters such as corrosion current (icorr), corrosion potential (Ector), cathodic Tafel slope (β_c) and anodic Tafel slope (βa) were derived from the tafel curves.

Table (1): Spectrometry Analysis Result of the Carbon Steel Sample

Element	C	Mn	Si	S	P	Fe
Comp.%	0.33	1.40	0.23	0.020	0.040	Rest

3. Results and discussion:

Figure (1) shown the effect of the corrosive media on carbon steel in absence and presence of different concentrations of potassium dichromate as corrosion inhibitor. It is shown that the corrosion rate of carbon steel increase with increasing the exposure time to corrosive media until presence of the inhibitor.

Also, as shown in figure (2) increasing the concentration of potassium dichromate due to decrease the corrosion rate because the potassium dichromate is known to be an effective corrosion inhibitor which protect the carbon steel from the HCl corrosive media.

The rate of corrosion was calculated from equation

$$\text{Corrosion rate} = \frac{\Delta W}{S \times t}$$

Where ΔW is the average weight loss of carbon steel samples, (S) is the exposed area of the samples in cm^2, and (t) is the immersed time

It is obvious that the presence of $Cr_2O_7^{2-}$ inhibits the corrosion of the carbon steel in HCl solution. The inhibition efficiency of this anion increases with increasing its concentration. The inhibitory effect of the dichromate may be due to the reduction of the Cr^{6+} to Cr^{3+} (as Cr_2O_3) during film formation

$$Cr_2O_7^{2-} + 8H^+ + 6e = Cr_2O_3 + 4H_2O$$

The presence of Cr_2O_3 in the passive film improves its protectiveness and hence inhibits the corrosion and anodic dissolution of iron.

Figure (3) shown the inhibition efficiency at different inhibitors concentrations were found to increase with increasing potassium dichromate concentration.

We illustrate the variation of the protection efficiency with the concentration of potassium dichromate where a value of (P % = 97.63) has been reached. we can calculate the inhibition efficiency from the following relation:

$$P\% = (W - W')/ W \times 100$$

where W and W' are the corrosion rate of carbon steel in the absence and presence of potassium dichromate, respectively, at given inhibitor concentration

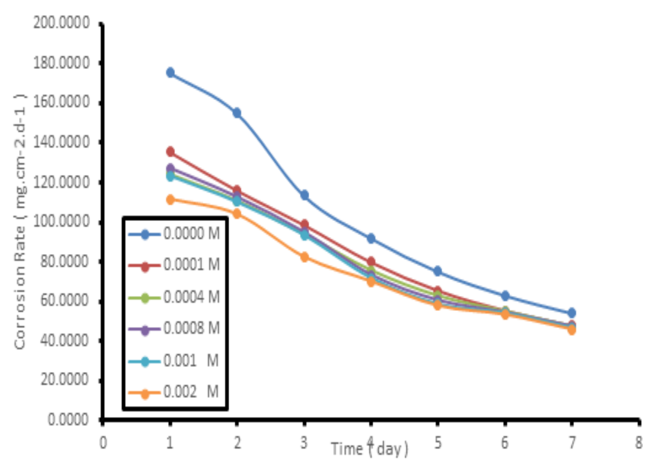

Fig (1): Rate of corrosion as a function to exposure time with different concentration

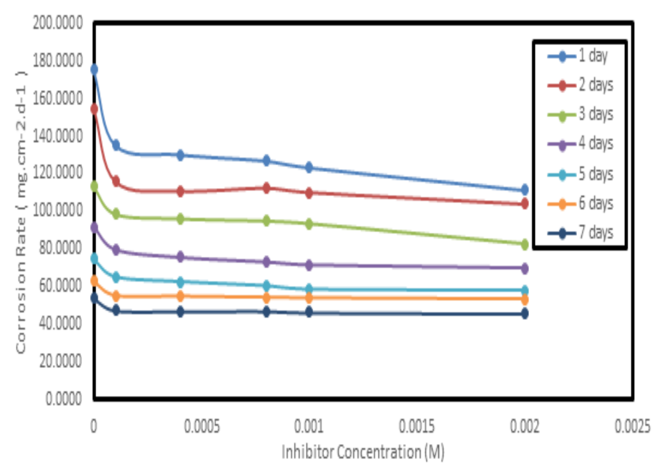

Fig (2): Rate of Corrosion as function to inhibitor concentration at interval time

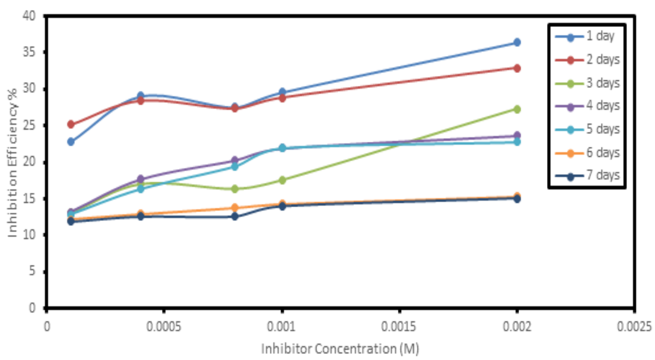

Fig (3): Inhibitor efficiency as a function to inhibitor concentration at interval time

Figure (4) illustrate the potentiodynamic cathodic and anodic polarization curves for carbon steel without and with different concentrations of $K_2Cr_2O_7$ in 1 M HCl solutions. It is clear that the presence of $K_2Cr_2O_7$ decreases the rates of corrosion of the samples.

It is found that the cathodic and anodic Tafel lines are almost parallel. These results indicate that both the cathodic and anodic reactions are charge transfer controlled. The electrochemical parameters E_{corr},, I_{corr} for the four samples are given in Table (2).

The rate of corrosion of each sample decreases with increasing $K_2Cr_2O_7$ concentration because the Potassium dichromate is known to be an effective oxidizing anodic inhibitor which protect the carbon steel from the HCl corrosive media by making it in passive state thus preventing breakdown of the passive oxide which can lead to uniform corrosion HCl Media Sample.

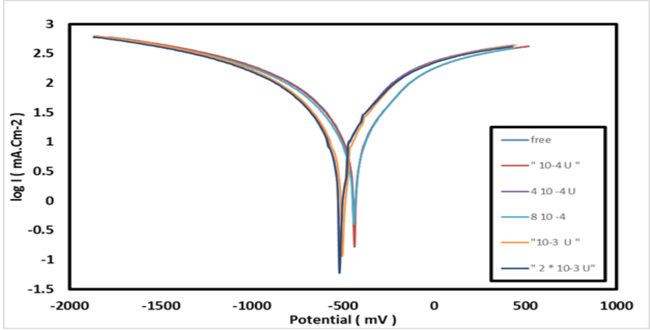

Fig (4): Polarization curves of Carbon steel sample in 1M HCl with different concentration of $K_2Cr_2O_7$.

Table (2): Electrochemical parameters of the carbon steel in 1 M HCl with different concentrations of $K_2Cr_2O_7$

Conc., M.	$-E_{corr}$	Ba	βc	I_{corr}	IE%	θ
Free	-435	279	304	6.56	-	-
10^{-4}	-442	256	323	6.25	4.7	0.047
4×10^{-4}	-515	244	299	5.61	14.5	0.145
8×10^{-4}	-439	276	286	5.54	15.5	0.155
10^{-3}	-502	269	271	5.40	17.7	0.177
2×10^{-3}	-515	264	269	5.02	23.5	0.235

4. Conclusion

From this work on potassium dichromate as Corrosion inhibitor on reinforcing carbon steel Bars we can get the following:

1- The Corrosion rate of carbon steel is increase with increasing the exposure time to the Corrosive media with absence or presence of the inhibitor.
2- The corrosion rate of carbon steel is decrease with increasing the concentration of potassium chromate as inhibitor.
3- The inhibition efficiency was found to increase with increasing the concentration of the potassium dichromate.

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